

SHIPPING CONTAINER

Spartan IR Camera for the SOAR Telescope

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1 Requirement

The shipping container must protect the instrument from damage. According to Gary Burgess of the MSU Department of Packaging, "For a 600+ lb load, two standards setting bodies list 3 drop heights: the "assurance level 1" drop height is the high end, the "assurance level 2" drop height is the average (what everybody uses), and "assurance level 3" is the low end. They are:

Industry survey:	AL1=9 inches	AL2=6"	AL3=3"
ASTM:	AL1=12	AL2=9"	AL3=6"

from *Test Method ASTM D4169 - Standard Practice for Performance Testing of Shipping Containers and Systems*, ASTM (American Society for Testing and Materials), 2003.

2 Design

The shipping container has four vertical assemblies (Figure 1) that operate in parallel. Each assembly uses two Miner GBR-10 bumpers in series. (Miner Elastometer of St. Charles, IL, minerelastometer.com.) In addition each assembly has two lateral GBR-5 bumpers. The lateral bumpers also provide friction, which lessens the load for the vertical bumpers.

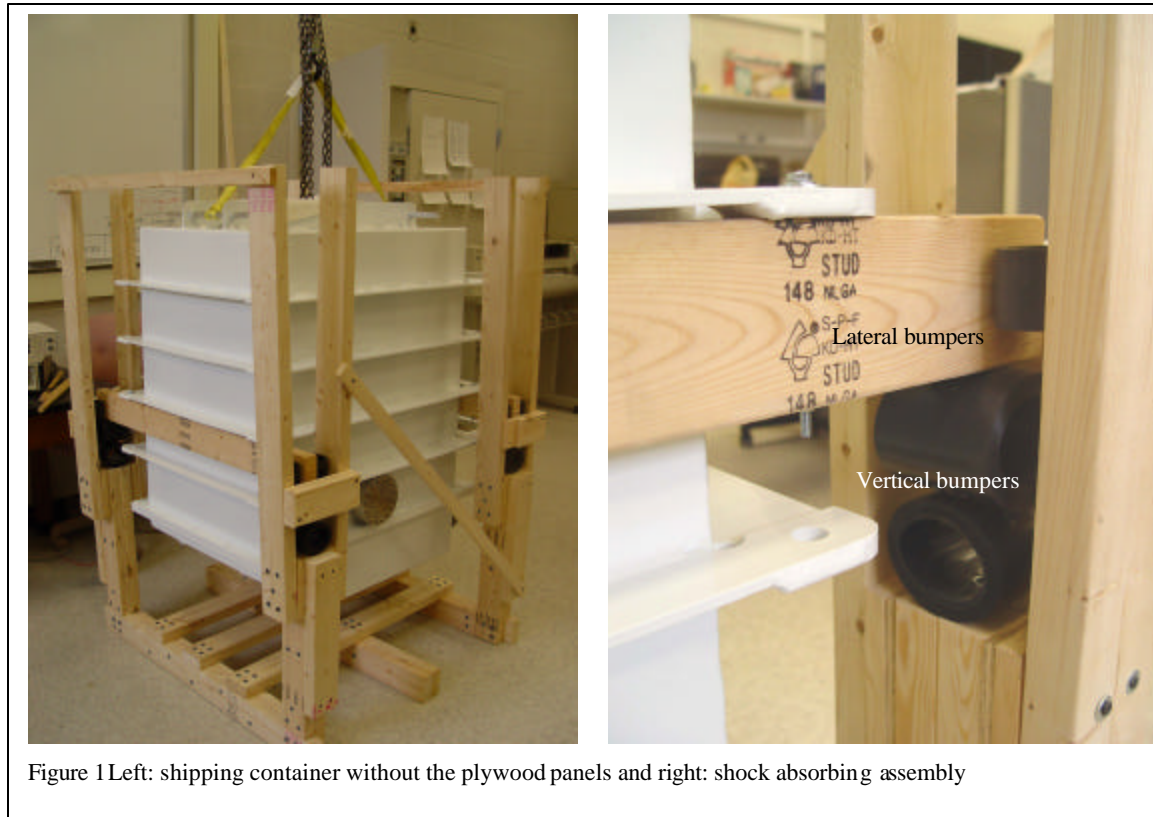


Figure 1 Left: shipping container without the plywood panels and right: shock absorbing assembly

Miner Elastometer provides a program MinerSize to compute the response of a bumper to a shock with a given mass and initial velocity. Since MinerSize does not allow for bumpers in series, we modify the equation of motion. For a single bumper, the equation of motion is

$$m y'' = -k (y - y_1) - m g$$

$$2m x'' = -k x - 2m g/2,$$

where y is the position of the load and one end of the bumper and y_1 is the position of the other end of the bumper. In the second equation x is the length of a single bumper, and $x = y/2$. Therefore, we can replace the coordinates of the load with the length of the bumper if the mass is doubled, gravity is halved, and the initial velocity is halved.

The results (Figure 2) show that for assurance level 1, the conservative choice,

- the stroke is 96% of the maximum, and
- the maximum acceleration is 7 times that of gravity.

The stroke is very close to the maximum. If the instrument were dropped from a greater height, the bumpers would bottom out, and the force becomes much greater.

The maximum acceleration of 7g is very gentle. A 3-kg mirror attached with three 6-32 bolts can withstand 800 g. The ribs by which the instrument attaches to the shipping container, can withstand 300 g without shearing off at the welds.

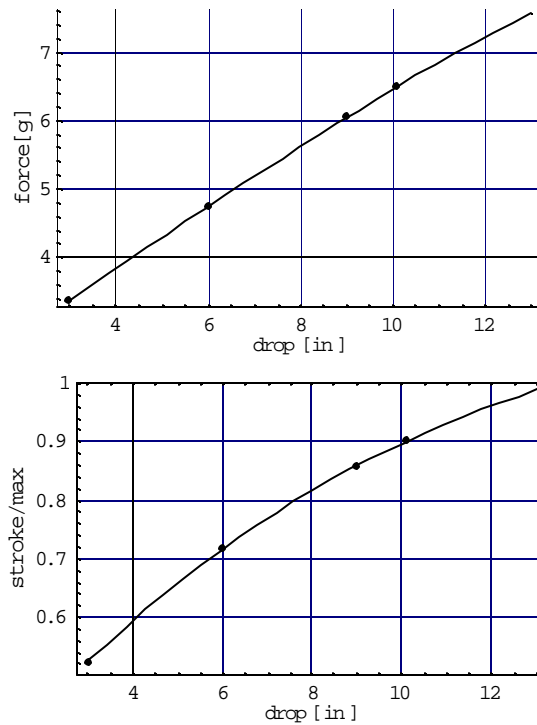


Figure 2 Maximum acceleration (top) and stroke as fraction of maximum (bottom) vs height of the drop. The line is an extrapolation of the points computed with MinerSize.